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ABSTRACT

The purpose of this investigation was to examine the interactive effects of prior mathematics preparation and instructional method on achievement in an introductory calculus course taught by both Personalized System of Instruction (PSI) and conventional approaches. Subjects were 248 university students, 60 from the self-paced method and 188 from the conventional method. Prior to the course all subjects completed the Mathematics Placement Examination (MPE). The results of the multiple regression analysis indicated significant effects due to both level of prior mathematics preparation and instructional method; and also a significant prior mathematics preparation x instructional method interaction. Supplementary analysis indicated that the range of MPE scores for which statistically significant differences in achievement scores existed was from 5 to 18. (WBC)

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INTERACTION OF PRIOR MATHEMATICS PREPARATION, INSTRUCTIONAL METHOD, AND ACHIEVEMENT IN THE SELF-PACED AND CONVENTIONALLY TAUGHT SECTIONS OF MATHEMATICS 295

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Report 9

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PREFACE

This is the second of two reports in the evaluation of Self-Paced Calculus during the 1975-76 academic year. The first report compared the self-paced and conventionally taught sections of Mathematics 295 in terms of student attitudes toward instruction and end-of-semester examination achievement. The findings of that report indicated significantly more positive attutudes toward the course as well as a significantly higher level of examination performance by students in the self-paced sections. The purpose of the study outlined in this report was to extend the investigation of differential examination achievement by determining whether the differences noted between the self-paced and conventional instructional methods were constant for all levels of prior mathematics preparation.

The report is divided into two parts. The first is a capsule summary of the method employed and the major findings. The second part is a fuller and considerably more detailed version of the study.

PART I

CAPSULE SUMMARY OF METHOD AND RESULTS

A considerable body of research has demonstrated the effectiveness of the Personalized System of Instruction (PSI) or the "Keller Plan" in improving students' attitudes toward a course, as well as in producing statistically significant gains in student achievement. One problem with most of this research, however, is that it treats comparative student performance in PSI and conventional courses globally. As a result, the presence of interactions between instructional method and learner traits and/or aptitudes may be masked. The purpose of this investigation was to examine the interactive effects of prior mathematics preparation and instructional method on achievement in an introductory calculus course taught by both PSI and conventional approaches.

METHOD

Course and Treatments

The focus of the study was the first semester of a four-semester introductory calculus sequence (Math 295) intended for potential science and mathematics majors. A number of sections were offered to students in a modified PSI format (entitled Self-Paced Calculus) which allowed for self-pacing, variable credit, optional attendance at lecture/problem solving sessions, scheduled tutorials for individual help and testing, and required mastery of a unit of material before proceeding to subsequent units. The conventional method consisted of three hours of lecture/problem solving sessions per week. Approximately 24 students were assigned to each class section. The classes were taught by both full-time faculty and graduate teaching assistants.

Subjects

The subjects in the study were 248 students, 60 from the self-paced method and 188 from the conventional method. Since all students who took the final examination in the self-paced method earned a semester grade of C or above (the rest being "drops" of F's), students receiving a D or F in the conventional sections were eliminated from the analysis.

Variables

In order to study the interaction between student traits and instructional methods without confounding the effects of the method, one needs to measure student traits prior to, or at the very beginning of, the course of instruction. Prior to beginning Math 295 each student in the study had completed the Mathematics Placement Examination (MPE). The MPE is a 33-item test which measures prior mathematics preparation, defining this construct as encompassing both aptitude and achievement.

The dependent variable (course achievement) was an eight-item, 132-point, common end-of-semester examination which covered the equivalent in content of the first eight units, or two credit hours, of material in the self-paced method. The test was constructed jointly by faculty members in both methods and scored by six independent judges who had no association with either the self-paced or conventional sections. Each judge scored only one part of the test for each student and was unaware of which instructional method any particular student was in. Students took the examination during the regular final examination period.

Design and Statistical Analysis

Because the self-paced alternative presented students with a dramatically different learning format from conventional methods, faculty were opposed to students' being assigned to it on the basis of chance. This prevented the random assignment of subjects to treatments and led to the adoption of a quasi-experimental approach. Quasi-experimental designs do not permit the same degree of causal inference as true experiments. The present design was considerably strengthened, however, by the demonstration of pre-treatment equivalence between the two instructional methods in MPE scores and a range of personality dimensions which included level of personal motivation.

Subsequent to a preliminary analysis which indicated that the relationship between MPE scores and semester examination scores for each instructional method was linear in nature, a multiple regression analysis was performed with semester examination scores as the predicted variable. The predictor variables were instructional method, MPE scores, and an interaction vector created by multiplying each student's instructional method by his or her MPE score. The critical level of significance for all statistical tests was set at the .01 level.

RESULTS

The results of the multiple regression analysis indicated significant effects due to both level of prior mathematics preparation and instructional method. The mean semester examination score for the self-paced method was 99.72 as compared to 82.28 for the conventional method. Furthermore, a significant prior mathematics preparation x instructional method interaction was also indicated. This latter finding suggests that, while the self-paced method demonstrated a significant overall improvement in examination achievement over the conventional method, the effects were not constant across all levels of prior mathematics preparation. Investigation of the slopes of the regression lines for each instructional method indicated that the effects of the self-paced method were most pronounced for students at the relatively lowest levels of mathematics preparation and tended to diminish in magnitude as level of mathematics preparation increased.

A supplementary analysis indicated that the range of MPE scores for which statistically significant differences in achievement scores existed between the two instructional methods was from 5 to 18. This represented approximately 81.9% of the distribution of subjects' MPE scores. Above a score of 18 on the MPE the overall mean achievement score for the self-paced method was still somewhat higher (9.44 points) than that for the conventional; however, the mean difference was not large enough to be considered statistically significant at the .01 level.*

Another way of regarding this interaction is by considering the differences in mean examination scores between the two instructional methods for different ranges of the MPE. For an MPE range of 5 - 12 (below one standard deviation below the overall mean) the mean examination score difference was 29.41 points in favor of the self-paced method; for an MPE range of 13 - 18 (one standard deviation on either side of the overall mean) the mean difference was 13.41 points in favor of the self-paced; for an MPE range of 19 - 26 (above one standard deviation above the overall mean) the mean difference was 9.44 points in favor of the self-paced method.

* The reader is referred to the Cautionary Note beginning on page 10 of the full report.

PART II

Based on the availability of an extensive body of research evidence, there appears to be little doubt about the effectiveness of the Personalized System of Instruction (PSI) or the "Keller Plan" (Keller, 1968) in improving both students' attitudes toward a course and their performance on a variety of course achievement measures. The basic features of PSI courses include the following: (a) individual student pacing; (b) mastery of a unit of material prior to proceeding to the next unit; (c) utilization of student tutors; (d) use of study guides to impart critical information; and (e) lectures for motivation and stimulation rather than for imparting information (Kulik, Kulik and Carmichael, 1974). Various modifications of these basic characteristics have been made in implementing PSI courses in diverse content areas.

Born and Davis (1974); Born, Gledhill and Davis (1972); Cooper and Greneir (1971); Green (1971) Riner (1972); Roth (1973); Shepard and MacDermot (1970) and Witters and Kent (1972) are all representative studies or reports which indicate that, when compared to conventional lecture approaches, the general PSI model produces significantly more positive student attitudes toward a course and/or significantly higher achievement. The results of these studies are from a variety of disciplines including psychology, physics, mathematics and engineering. A comprehensive review of PSI in science teaching is provided by Kulik, Kulik and Carmichael (1974).

One potential problem with the studies cited above, and indeed with most PSI investigations, is that they treat comparative student performance in PSI and conventional courses globally. As a result, they may mask the presence of interactions between distinctive instructional treatments, on the one hand, and different learner traits and/or aptitudes, on the other. It may be that the effects of PSI, or any individualized instructional system for that matter, are not homogeneous across the full range of aptitudes or personality orientations which the student brings to the course. Thus, PSI may be most effective for a subgroup of students at certain levels of a particular trait, while conventional methods may be more appropriate with another subgroup of students at different levels of the same trait. For still another subgroup, achievement may be unaffected by instructional treatment.

Unfortunately, it is only recently that researchers have attempted to disaggregate the global effects of PSI (Fernald, et al., 1975) or to relate performance in PSI courses to learner traits and/or abilities (e.g. Johnson

and Croft, 1975; Born, Gledhill and Davis, 1972; Morris and Kimbrell, 1972; Austin and Gilbert, 1973 and Kulik, Kulik and Milholland, 1974). The results of this research are not particularly conclusive. Some studies indicate that lower ability students benefit most, in terms of achievement, from the Keller Plan; others suggest that the greater benefits accrue to higher ability students, and still others suggest that students in PSI courses improve a constant amount in achievement regardless of ability level. Despite their equivocal nature, however, the findings of these studies clearly suggest that there may be a significant relationship between prior student aptitudes and achievement, and the effectiveness of the PSI instructional method. The purpose of the present investigation was to examine the effects of the interaction of prior mathematics preparation and instructional method on achievement in an introductory calculus course taught by both PSI and conventional approaches.

METHOD

Course and Treatments

The focus of the study was the first semester of a four-semester introductory calculus sequence (Math 295) intended for potential science and mathematics majors. The course typically enrolls over 300 students in the first semester. A number of sections were offered to students in a modified PSI format (entitled Self-Paced Calculus) which allowed for self-pacing, optional attendance at lecture/problem solving sessions, scheduled tutorials for individual help and testing, and required mastery of a unit of material before proceeding to subsequent units. An additional feature of the course was variable credit. Students were required to earn a minimum of 2 credit hours during the semester (in lieu of the traditional 3 credit hours). No specific limit was set on the maximum number of credit hours that could be earned. The number of credit hours earned was tied to the number of unit tests passed.

The conventional method of instruction consisted of three hours of lecture/problem solving sessions per week. Approximately 24 students were assigned to each class section. The classes were taught by both full-time faculty and graduate teaching assistants. Both the conventional and self-paced methods covered essentially the same content and both methods used the

same primary textbook: Analytic Geometry and the Calculus, 3rd Edition, by A. U. Goodman.

Subjects

The subjects in the study were 248 students, 60 from the self-paced method and 188 from the conventional method. Since all students who took the final examination in the self-paced method earned a semester grade of C or above (the rest being "drops" or F's), students receiving a D or F in the conventional sections were eliminated from the analysis. The drops or F grades for the self-paced method were 28.6%. This compared to 22.1% of the conventional method receiving a grade of D, F or incomplete. Of the 60 students in the self-paced method, 43 earned two credit hours and 17 earned three or more credit hours.

Variables

In order to study the interaction between student traits and instructional methods without confounding the effects of the method, one needs to measure student traits prior to, or at the very beginning of, the course of instruction. Prior to beginning Math 295 each student in the study had completed the Mathematics Placement Examination (MPE) (Myerberg and Kelly, 1972). The MPE was validated on a sample of 1422 students in eleven undergraduate mathematics courses at Syracuse University. It was found to correlate .48 with first-semester grades in Math 295. This compared with a correlation of .45 between first semester Math 295 grades and the Mathematics score of the Scholastic Aptitude Test. The MPE was used in place of the MSAT because scores on the latter measure were not available for all subjects in the study.

While the MPE ostensibly measures a student's prior level of achievement in mathematics skills, its correlation of .59 with the MSAT suggests that it is quite probably also a measure of mathematics aptitude. For this reason it will be regarded in the present study as a measure of prior mathematics preparation, defining this construct as encompassing both aptitude and achievement. The computed Kuder-Richardson 20 (internal consistency) reliability coefficient for the MPE is .84.

The dependent variable (course achievement) was an eight-item, 132-point, common end-of-semester examination which covered the equivalent in

content of the first eight units, or two credit hours, of material in the self-paced mthod. The test was constructed jointly by faculty members in both methods and scored by six independent judges who had no association with either the self-paced or conventional sections. Each judge scored only one part of the test for each student, and was unaware of which instructional method any particular student was in. The split-half reliability of the examination adjusted by the Spearman-Brown formula was .72.

Design and Statistical Analysis

Because the self-paced alternative presented students with a dramatically different learning format from conventional methods, faculty were opposed to students' being assigned to it on the basis of chance. This prevented the random assignment of subjects to treatments and led to the adoption of a quasi-experimental approach. The quasi-experimental design employed was a pre-post, non-equivalent control group design (Campbell and Stanley, 1963) in which the subjects could elect to take the self-paced option. Since the primary threat to internal validity in this design stems from possible self-selection bias (e.g. students with higher mathematics preparation electing to take the self-paced method), the design is considerably strengthened if equivalence can be demonstrated on pre-treatment variables which may have significant correlation with the dependent variable (Campbell and Stanley, 1963).

Differences between the conventional and self-paced students in the means and variances of the MPE were both non-significant. The F ratio for the difference between MPE means was 1.15 with 1 and 246 degrees of freedom ($p > .30$), while the ratio of the group variances fell within the upper and lower rejection regions of the F distribution at $p > .25$ (Hays, 1963). (Note: by statistical convention a difference is considered non-significant or unreliable if it has a greater than .05 probability of being due to chance.)

Additionally, pre-enrollment scores on the Activities Index (AI), a 12-dimension measure of personality needs were available for 132 students from the conventional method and 47 students from the self-paced method. The AI is a widely used personality inventory consisting of the following subscales: Self-Assertion, Audacity-Timidity, Intellectual Interests, Motivation, Applied Interests, Orderliness, Submissiveness, Closeness, Friendliness, Expressiveness-Constraint, Egoism-Diffidence and Sensuousness.

A multivariate analysis of variance yielded non-significant differences between the self-paced and conventional groups along all twelve personality need scales of the AI. For both males and females the multivariate test was non-significant. The multivariate F-ratio for males was .360 with 12 and 124 degrees of freedom ($p > .60$) while the multivariate F for females was .911 with 12 and 29 degrees of freedom ($p > .60$). Thus, even though strict experimental controls were not possible in the study, the self-paced and conventional groups, nevertheless, appear to be quite similar in terms of both prior mathematics preparation and a range of personality dimensions.

Demonstrating such pre-treatment equivalence between groups in quasi-experimental designs does not permit the same kinds of causal inferences as do true experiments in which subjects can be randomly assigned. Clearly self-selection could have created pre-treatment bias in unmeasured variables which may affect achievement--an unequivocal limitation of the present study. However, the above evidence strongly suggests that self-selection did not create pre-treatment bias across a wide range of learner characteristics, including levels of prior mathematics preparation and personal motivation.

Multiple regression analysis with semester examination scores as the predicted variable was the mode of statistical analysis employed. The predictor variables were instructional method, Mathematics Placement Exam scores, and an interaction vector created by multiplying each student's instructional method by his or her MPE score. Instructional method was effect coded according to Kerlinger and Pedhazur (1973). Students in the self-paced method were coded 1 and students in the conventional method were coded -1. In computing the multiple regression the effects of instructional method were computed while controlling for MPE scores, the effects of the MPE were computed while controlling for instructional method, and the effects of the MPE x instructional method interaction were computed while controlling for both instructional method and MPE scores. The critical level of significance for all statistical tests was set at the .01 level.

RESULTS

A preliminary analysis was conducted for each instructional method to determine if the relationship between MPE scores and semester examination

scores was linear or curvilinear. In both instructional methods the test for deviation from linearity (Kerlinger and Pedhazur, 1973) was non-significant ($p > .10$). This suggests that a linear relationship best characterized the association between prior mathematics preparation and examination achievement.

Table 1 shows the results of the multiple regression analysis of semester examination scores. The total variance accounted for by instructional method, MPE scores and the MPE x instructional method interaction was 26.75% (multiple R = .517, F = 29.70 with 3 and 244 degrees of freedom, $p < .001$). As the table indicates the effects due to level of prior mathematics preparation and instructional method were both statistically significant. The mean semester examination score for the self-paced method was 99.72 as compared to 82.28 for the conventional method. Furthermore, a significant prior mathematics preparation x instructional method interaction was also indicated--although the magnitude of this effect was relatively small, as indicated by the modest proportion of variance in examination scores for which it accounted.

The finding of a significant mathematics preparation x instructional method interaction suggests that, even though the self-paced method demonstrates a significant overall improvement in examination achievement over the conventional method, the effects are not constant across all levels of prior mathematics preparation. Another way of conceptualizing this interaction is by considering the slopes of the linear regression lines, which, in part, represent the relationship between the MPE and examination achievement for each instructional method. (The regression lines represent the least squares linear fit to the data.) If no interaction is present, i.e., if one method is superior to the other by a constant amount across all levels of prior mathematics preparation, the slopes of the regression lines will be parallel. On the other hand, if some interaction is present the effects of instructional method are not constant across all levels of mathematics preparation and the slopes of the regression lines will deviate significantly from parallel.

The statistically significant MPE x instructional method interaction shown in Table 1 indicates that the slopes of the regression lines representing the relationship between prior mathematics preparation and examination achievement are not parallel. Figure 1 depicts the least squares regression lines fitted to the data from both instructional methods. The regression equations for the two methods are as follows (where X is the score on the MPE and Y is

TABLE 1

SUMMARY OF MULTIPLE REGRESSION ANALYSIS (N=248)

VARIABLE	PROPORTION OF VARIANCE[a]	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F
MATHEMATICS PLACEMENT EXAMINATION - MPE (A)	.1317	16053.04	1	16053.04	43.97**
INSTRUCTIONAL METHOD ADJUSTED FOR MPE SCORES (B)	.0971	11808.72	1	11808.72	32.34**
A x B	.0217	2637.81	1	2637.81	7.23*
RESIDUAL	.7325	89079.80	244	365.08	

* $p < .01$

** $p < .001$

[a] Proportions of variance do not sum to 1.00 because unequal numbers of subjects in each instructional method lead to correlations among variables.

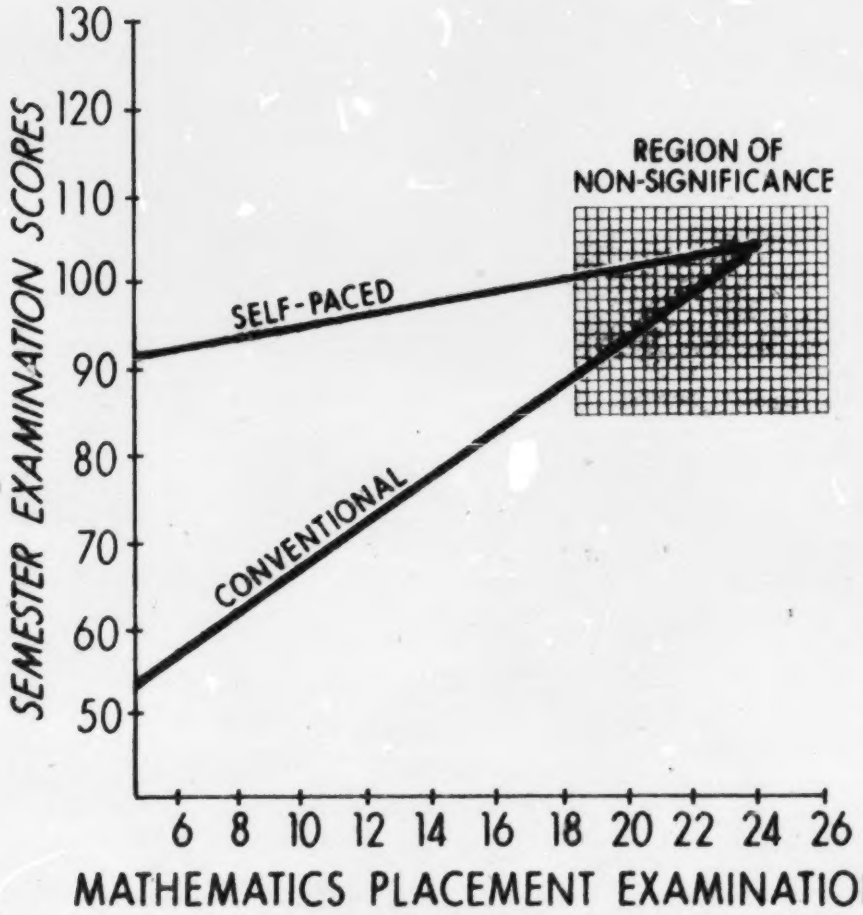

Figure 1: MATHEMATICS PREPARATION X INSTRUCTIONAL METHOD INTERACTION

the score on the semester examination):

Conventional: $Y = 2.609X + 43.276$

Self-Paced : $Y = 0.725X + 88.424$

Although the regression line for the self-paced method is higher than that for the conventional method across the full range of MPE scores, there is a clear indication that the lines are not parallel. The regression lines are furthest apart at the lowest measured levels of prior mathematics preparation and tend to converge as level of mathematics preparation increases. This suggests that, while there is an overall significant improvement in examination achievement associated with the self-paced method, the effects of that method in improving achievement are most pronounced for students at the relatively lowest levels of mathematics preparation and tend to diminish in magnitude as level of mathematics preparation increases.

Furthermore, as represented in Figure 1, the relationship between prior mathematics preparation and scores on the semester examination is considerably stronger for the conventional than for the self-paced method. For every increase of one point on the MPE there is an average increase of approximately 2.6 examination score points for the conventional method. This corresponded to an average increase of 0.73 points for the self-paced. A further indication of this tendency is shown by the respective correlations between the MPE and examination achievement for the two instructional methods. The correlation in the conventional method was .434 as compared to .217 in the self-paced. In terms of the variance in examination achievement accounted for by prior mathematics preparation the percentages were 18.84% in the conventional and 4.73% in the self-paced. (Percentage of variance accounted for is determined by squaring the correlation coefficient.)

Regions of Significance and Non-Significance

A supplementary analysis was conducted with a technique developed by Johnson and Neyman (1936) which permits the determination of the range of MPE scores for which it is reasonable to assume that achievement differences

between the two methods are statistically reliable or significant.*

The basic statistics necessary to conduct the Johnson-Neyman analysis are shown in Table 2. The results of the analysis indicated that the range of MPE scores for which statistically significant differences in achievement scores existed between the two instructional methods was from 5 to 18. This represented approximately 81.9% of the distribution of subjects' MPE scores. Above a score of 18 on the MPE the overall mean achievement score for the self-paced method was still somewhat higher than that for the conventional; however, the mean difference was not large enough to be considered statistically significant at the .01 level. For the purposes of the study this range of scores on the MPE above 18 has been termed the region of non-significance, and is depicted in Figure 1 by the shaded area. The region of non-significance represented only 18.1% of the total distribution of MPE scores.

Another way of regarding this interaction is by considering the mean differences in examination scores between instructional methods for different ranges of the MPE. Table 3 shows differences between examination score means for the ranges 5-12, 13-18, and 19-26 on the MPE. The range 5-12 represents the area below one standard deviation below the mean, the range 13-18 represents one standard deviation on either side of the mean, and the range 19-26 represents the area above one standard deviation above the mean. As the table indicates, self-paced students tended to have higher mean examination scores across the full range of MPE scores. However, it is clear that the most dramatic differences were for students whose MPE scores were below one standard deviation below the mean, i.e., an MPE score range of 5-12.

Cautionary Note

While the linear regression lines in Figure 1 represent the most accurate general characterization of the overall data, it will be noted that they are not extended beyond the point of intersection, which falls within the region

*Note: If one assumes that the 248 students in this study represent the total population of students in Math 295 receiving a grade of C or above, then tests for statistical significance are not necessary. However, if the students in this study are regarded as a sample generally representative of a population of students who have or will be taking Math 295, then inferential tests of significance are appropriate.

TABLE 2

BASIC STATISTICS FOR JOHNSON-NEYMAN ANALYSIS

	SELF-PACED (N=60)	CONVENTIONAL (N=188)
MATHEMATICS PLACEMENT EXAM		
mean	15.58	14.95
s.d.	4.17	3.76
SEMESTER EXAMINATION SCORES		
mean	99.72	82.28
s.d.	13.90	22.65
INTERCEPT	88.42	43.28
SLOPE	0.73	2.61
ERROR SUM OF SQUARES	89079.8	

TABLE 3

MEAN EXAMINATION SCORE DIFFERENCES FOR THREE RANGES OF MATHEMATICS PLACEMENT EXAMINATION (MPE) SCORES

MPE SCORE RANGES	SELF-PACED MEAN	CONVENTIONAL MEAN	DIFFERENCE BETWEEN MEANS
5 - 12 BELOW ONE STANDARD DEVIATION BELOW THE MEAN	98.64 (N = 14)	69.23 (N = 48)	29.41
13 - 18 ONE STANDARD DEVIATION ON EITHER SIDE OF THE MEAN	97.28 (N = 32)	83.87 (N = 109)	13.41
19 - 26 ABOVE ONE STANDARD DEVIATION ABOVE THE MEAN	106.35 (N = 14)	96.91 (N = 31)	9.44

of non-significance. To do so may have been somewhat misleading in that it would have indicated that the conventional method begins to become superior to the self-paced (in terms of examination achievement) beyond an MPE score of 24. This is not supported by the actual data. Although the two instructional methods do not show statistically significant mean examination score differences for the total range of MPE scores from 18-26, if one considers only MPE scores from 22-26, the self-paced method shows a substantial mean improvement in examination scores over the conventional. Moreover, if one computes the separate linear regressions for both instructional methods, while restricting the range of interest to MPE scores from 19-26, the relationship between MPE scores and semester examination scores tends to become stronger in the self-paced method and weaker in the conventional method.

Because so small a number of cases falls within these restricted MPE score ranges, however, the reliability of such findings is highly suspect. It would be extremely risky, therefore, to posit some significant change in the overall linear characterization of the data as depicted in Figure 1. Nevertheless, this finding may suggest that additional investigation is warranted to determine the possibly differential benefits of the two instructional methods for students with the highest levels of prior mathematics preparation. If such an investigation is to provide reliable findings, data will be required from substantially greater numbers of students with high MPE scores than are available in this study.

SUMMARY AND CONCLUSIONS

When compared to a conventional instructional method, the self-paced method was associated with a substantial and statistically significant overall improvement in mean semester examination scores even after controlling for level of prior mathematics preparation. The effects of the self-paced method in terms of improving achievement, however, were not constant across all levels of prior mathematics preparation (as measured by the Mathematics Placement Examination). The effects of the self-paced method were most pronounced for students with the lowest levels of prior mathematics preparation and tended to diminish as level of mathematics preparation increased. Up to, and including an MPE score of 18 the mean examination performance of self-paced students could be considered a statistically significant improvement ($p < .01$) over the mean examination

performance of conventional students. This region of statistically significant differences encompassed 81.9% of the total distribution of 248 students. For an MPE score of 19 or above, differences in mean examination scores between the two treatments could not be said to be statistically significant at $p < .01$--although the mean for the self-paced was higher than that for the conventional.

The findings also suggest that level of prior mathematics preparation has a somewhat stronger association with semester examination achievement in the conventional method than in the self-paced. The Mathematics Placement Examination accounted for 18.84% of the variance in semester examination scores for the conventional method. This compared with 4.73% in the self-paced method.

Two general hypotheses appear to be warranted by the above findings. First, it would seem that the unique instructional features of the self-paced instructional method--in particular the requirement of demonstrated unit mastery and the provisions for self-pacing--act to reduce the association between prior mathematics preparation and subsequent course achievement. Second, the analysis suggests that with the possible exception mentioned in the Cautionary Note, as level of prior mathematics preparation decreases the effects of the self-paced method in improving achievement over the conventional method tends to become more pronounced. In short, while the exam performance of the self-paced students tends to be higher than that of the conventional students across the entire range of scores on the MPE, the most dramatic differences exist for students at the relatively lowest levels of prior mathematics preparation.

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